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COLLEGE OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

BERKELEY, CALIFORNIA 94720-1740

October 29, 1996

*Final
11-02-96
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10/1/96*Rachel Khattab, Director
NASA Ames University Consortium Office
MS 223-9
NASA Ames Research Center
Moffett Field, CA 94035-1000

Final Report NCC 2-5035

Dear Ms. Khattab:

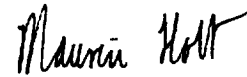
Work completed under the above Consortium is reported in the following Summary of research

Numerical simulation of a two-dimensional airfoil controlled by an applied moment in pitch and an airfoil controlled by jets are investigated. These simulations couple the Reynolds-averaged Navier Stokes equations and Euler's equations of rigid body motion with an active control system. The simulation of a step in altitude was performed for both systems with a free stream Mach number of 0.3. The airfoil controlled by a pitching a moment used an optimal state feedback controller. The feedback gains were calculated using a Linear Quadratic Regulator method. This simulation compared very well with a quasi-steady aerodynamic model showing a measure of validation of the nonlinear coupled system. Robust control design methods were used to develop a controller for the airfoil with jets. The linear model used to design the robust controller for the airfoil with jets. The linear model used to design the robust controller was identified from input/output data generated by open-loop simulations of the nonlinear coupled system. Simulation of the airfoil with jets showed that the designed controller was able to track the desired altitude trajectory. This simulation also showed oscillations in the control jets which resulted in mild oscillations in the attitude and vertical velocity of the airfoil not predicted by the linear model. The results of this research begin to provide a control system designer with a means of computationally evaluating an aircraft control system in problematic nonlinear flight regimes.

The summary covers three papers presented at professional conferences or in course of publication.

1. Allan, B.G., Atwood, C.A. and Packard, A., "Control System Analysis in Nonlinear Flight Regimes," AIAA Guidance, Navigation, and Control Conference, Scottsdale, AZ, Aug. 1994. AIAA Paper 94-3544.
2. Allan, Brian G., Packard, Andy and Holt, Maurice, "Multidisciplinary Control Design for a Two-Dimensional Airfoil with Jets," Proceedings of the 15th International Conference on Numerical Methods in Fluid Dynamics, Monterey, CA, June 1996.
3. B. Allan, M. Holt and A. Packard, "Simulation of a Controlled Airfoil with Jets," 35th AIAA Aerospace Sciences Meeting, Reno, NV. Jan. 1997.

Sincerely yours,

A handwritten signature in black ink, appearing to read "Maurice Holt". The signature is written in a cursive, flowing style.

Maurice Holt, P.I.

xc: Dr. Eugene L. Tu
Ms. Patricia Gates